MODEL ANSWER FOR PAPER AU-5031

DEPARTMENT OF CIVIL ENGINEERING, INSTITUTE OF TECHNOLOGY, GGV, BILASPUR

BTECH IIIrd SEMESTER, CIVIL ENGINEERING

SUBJECT: CIVIL ENGINEERING MATERIALS AND CONCRETE TECHNOLOGY

CLASS- **BTECH IIIrd SEMESTER** SUBJECT CODE: **21CE04T** BRANCH-**CIVIL ENGINEERING**

TIME: **3 HOURS** MAX. MARKS: **60**

NOTE: 1) All questions of Section-A is compulsory
2) Answer any one part from each unit of section-B

SECTION-A (10x2=20 Marks)

A-I Give the chemical classification of rocks with examples. **02**

According to chemical classification, rocks are of three types

I. Silicious rocks – rocks having maximum amount of free silica (ex. Granite, Quartzite etc.)
II. Argillaceous rocks – rocks having maximum amount of clay (ex. Slate, Laterite etc)
III. Calcareous rocks – rocks with predominate calcium carbonate (ex. Lime stone,Marble tc.)

A-II What do you mean by "frog" in a brick? Give its functions. **02**

A frog is a depression on one of the wide faces of a brick where generally the name of the brick manufacturer is embossed. The necessity of providing a frog is to act as a shear key between the mortar and the brick.

A-III What is meant by PVC? List out its applications in civil engineering. **02**

PVC means Poly Vinyl Chlorite, a polymer . The PVC is used in most of the civil engineering applications such as

I. Pipes and pipe fittings
II. Water Tanks
III. Doors
IV. 4) Windows etc.

A-IV What is neoprene rubber? Give the situations of its use.. **02**

Neoprene rubber is a special purpose synthetic rubber. It is having special qualities to suit different purposes. It is used for bearings for bridges.

A-V What is setting action of cement? Elaborate? **02**

When water is added to cement, the ingredients of cement react chemically and form complicated compounds. First , a cement paste is formed which slowly thickens. In about 30 minutes, it is said to have attained its initial set. In about 10 hours, it becomes rock hard and is said to have reached its final set.be

A-VI Give out the sizes of coarse aggregates used for Foundations, beams, columns and slabs? **02**

The sizes of coarse aggregates used for Foundations is 40mm, beams is 20mm, columns is 20mm and slabs is 20mm

A-VII What do you mean by shrinkage of concrete? **02**

Contraction of concrete in the absence of load is known as shrinkage. It may be plastic shrinkage due to absorption of water by aggregates etc. or drying shrinkage due to absorption of capillary water after the concrete has set.

A-VIII What is durability of concrete, Give the factors affecting durability? **02**

A durable concrete is one that performs satisfactorily under anticipated exposure conditions for stipulated life of the structure. The various factors affecting the durability of concrete used in normal conditions are permeability, Frost action, Sulphate attack, Carbonation, Mineral oils, Organic acids, Vegitables and Animal Oils and Fats, Sugar, Sewage etc.

A-IX Give the advantages of smart concrete. **02**

Advantages of smart concrete

1) its property can be altered
2) It can measure the stresses
3) Loading on the member can be assessed.
4) Environment of the concrete can be assessed.
5) Monitoring of concrete structure with realt ime data

A-X List out the situations where shortcrete is applied. **02**

Situations where shortcrete is applied are

1) Earthen slopes where stability of slope is problematic.
2) Tunnel lining
3) Embankments of dams and reservoirs etc.

SECTION-B (5x8=40 Marks)

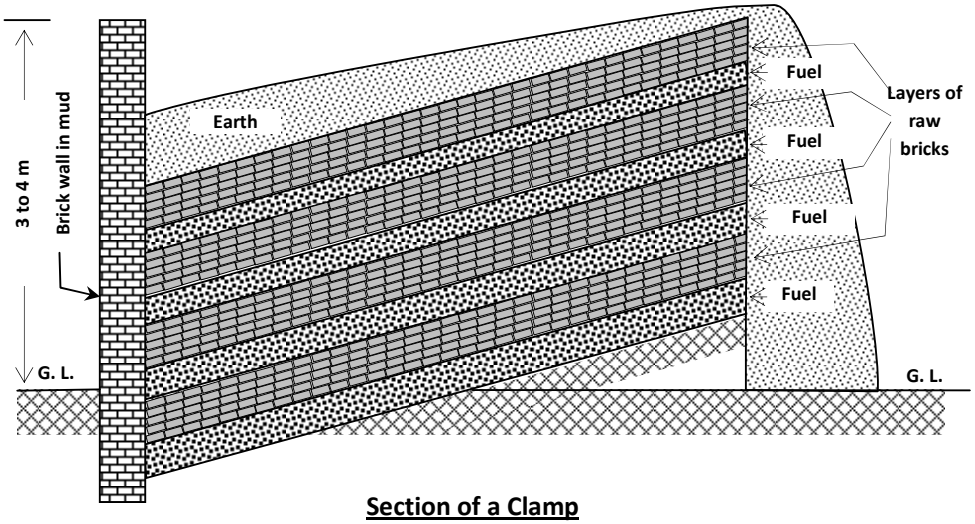
UNIT-I

B-I (a) Explain with a neat sketch, the burning of bricks in clamps or pazawah and give its advantages **08**
or
(b)Explain with neat sketches, the shapes and sizes of various roofing tiles along with their laying and fixing to roof.

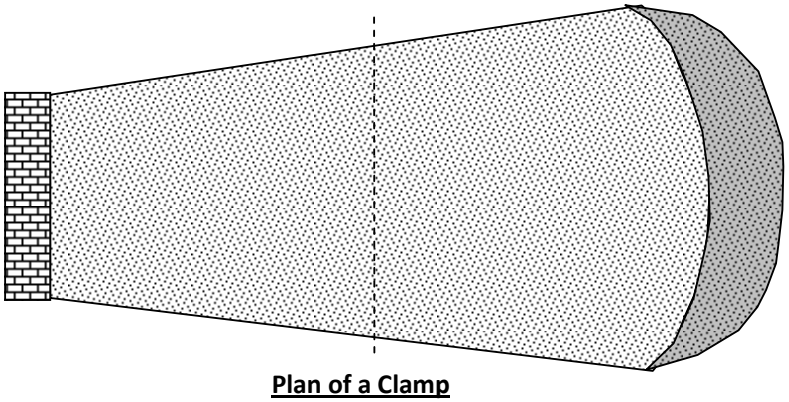
Clamps are temporary structures used for burning of bricks on a very small scale. The basic structure of a clamp consists of alternate layers of fuel and dried bricks. Generally the floor is prepared in such a way that it looks trapezoidal in plan with the floor of the shorter end in excavation, whereas it is raised with an inclination of 15° up to and over the ground level towards the wider end, in cross-section. A brick wall in mud is provided at the shorter end.

Firstly, a layer of fuel (about 700mm to 800mm) consisting of grass, leaves, cow dung, litter, husks of rice or ground nuts and sometimes either wood or coal dust etc. is laid on the prepared floor. Then, a layer (consisting of 4 or 5 courses) of raw bricks with provision of small spaces in between bricks is laid on edges for the circulation of air.

A second layer of fuel is then placed and then a new layer of raw bricks is repeated over it. Similarly alternate layers of fuel and raw bricks are formed. The thickness of fuel layer gradually decreases as it reaches the height of the clamp. The total height of clamp is about 3 to 4m.



Section of a Clamp



Plan of a Clamp

The rocks may be classified on the basis of their a) geological formation, b) physical characteristics, c) chemical composition and also d) based on the hardness as follows

The various advantages and disadvantages of burning bricks in clamps are

(a) Advantages of clamp burning

I. No skilled labour and supervision is required
II. The fuel is the wastes and thus economical (grass, cow dung, litter, rice husk)
III. Bricks burn and cool slowly and thus bricks produced by clamps are strong and tough
IV. Initial experience is very small

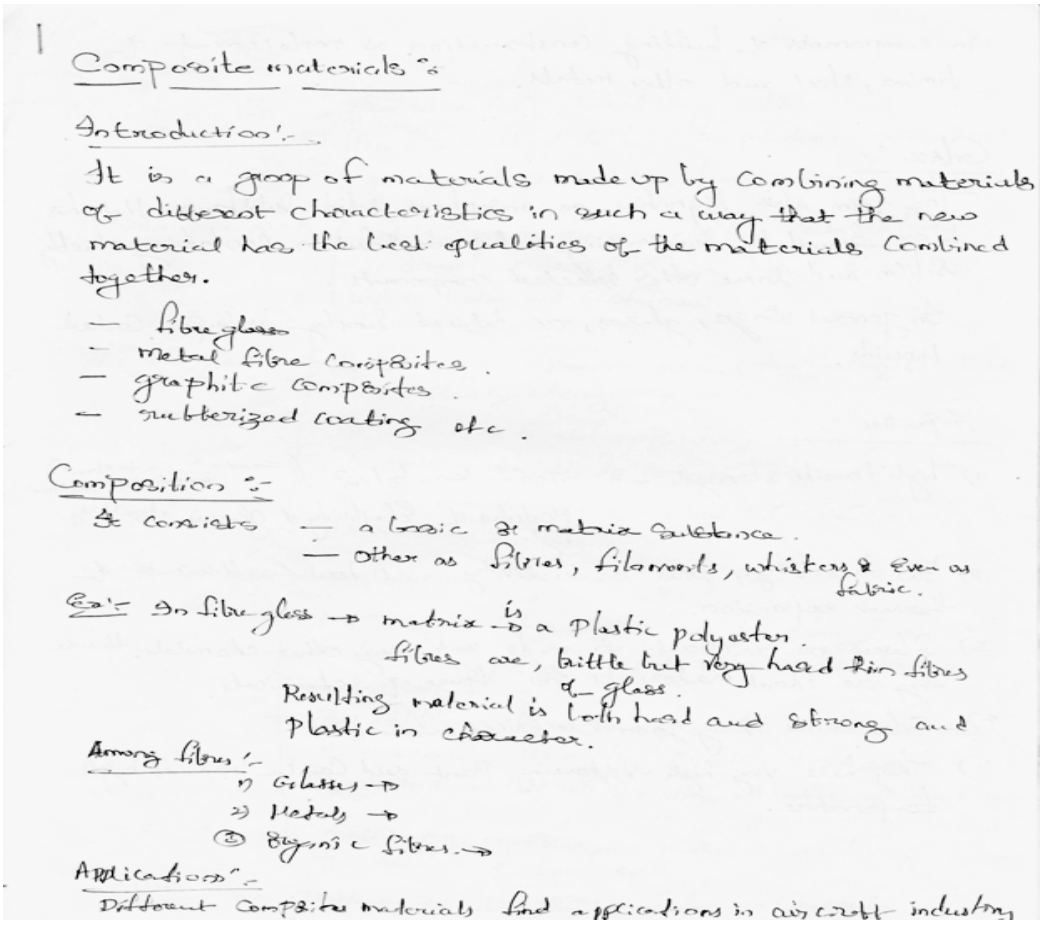
(b) Disadvantages of clamp burning

I. It is a very slow process.
II. There is no control of fire in the clamp.
III. Quality of bricks is not uniform as bricks near the bottom are overburnt and those near sides and top are under burnt.
IV. Bricks are not of regular shape. It may be due to settlement of the bricks when fuel near bottom is burnt.
V. Clamps yield about 60% first class, the remaining 40% are over burnt or under burnt.

or

UNIT-II

B-II a) Give the characteristics properties and types of composite materials along with their specific uses **08**
or
(b)Mention the differences in the characteristics properties of paints, varnishes and distempers



Composite materials :-

Introduction :-
It is a group of materials made up by combining materials of different characteristics in such a way that the new material has the best qualities of the materials combined together.

- fibre glass
- Metal fibre composites
- graphite composites
- rubberized coating etc.

Composition :-
It consists — a basic or matrix substance.
— other as fibres, filaments, whiskers & even as fabric.

Eg :- In fibre glass → matrix is a plastic polyester.
fibres are, brittle but very hard thin fibres of glass.
Resulting material is both hard and strong and plastic in character.

Among fibres :-
1) Glasses →
2) Metals →
3) Organic fibres →

Applications :-
Different composite materials find applications in aircraft industry

in components of building construction as replacement of timber, steel and other metals.

Glass :-

The term glass signifies an amorphous solid substance that has been formed by supercooling a liquid solution containing chiefly silica and some other selected compounds.

In general usage, glasses are defined simply as super cooled liquids.

Properties :-

1) high tensile strength → 700 to 1400 kg/cm² (= 70 N/mm² to 140 N/mm²)
   Modulus of Elasticity of glass is also very high.
2) low ductility, low conductivity and low coefficient of thermal expansion.
3) Glasses are resistant to acids and many other chemicals. Hence they are ideal materials for storage of chemicals.
4) Glasses are very good electrical insulators
5) They have very high softening point and can be used at high temperature.

or

Paints :-

A paint is essentially a coating or covering material applied on a metallic or non-metallic surface and is defined as a "dispersion of a pigment in a suitable drying oil in the presence of a solvent called thinner or diluent.

Ingredients :-

- a Pigments → Real colouring substance
- a Solvent → in which the pigment is dissolved.
- a drier → which is necessary to quicken the process of evaporation.

Other Surface finishes :-

Varnish :- a varnish contains no pigment, instead, it has a resinous substance dissolved in a suitable oil or volatile liquid.

Lacquer :- A lacquer is a finishing material which is a dispersion of resins and cellulose esters in a volatile solvent. It dries quickly by evaporation of solvents

An Enamel : An Enamel is a blend of a paint with a varnish giving finish that is strong, durable and brilliant at the same time.

Functions :-

Paints are applied on metallic and non-metallic engineering surfaces for two reasons.

1) Protecting them against deterioration by atmospheric agencies.
2) Developing a decorative effect.

Characteristics :-

1) Good hiding power.
2) Permanent colour → must maintain its clear undercoat condition.
3) Resistance to corrosion → chemically inert
4) Easy application → shall spread easily, smoothly & uniformly
5) Economical in cost → should be low

Types of paints :-

1) Cold water paints → Consists of mineral pigments that are carried in water in the presence of a binder. ↳ used for interior.
2) Oil Paints → Drawn Paints quite useful for ordinary uses. (Hardens because of oxidation of linseed oil.)
3) Enamel Paints → ready made paints consists of whitelead & zinc white. (used for interior & exterior) Resistant to chemical attack.
4) Lacquers → given earlier.
5) Emulsion Paints → It is a suspension of one liquid with in another liquid. (Latex Paints used for painting wood and cement plaster)
6) Synthetic paint resins → high quality paints (used in automotive industry)
7) Aluminium Paints → Contain large emulsion in water.
8) Cement Paints → Emulsion of very fine flakes of aluminium in water.
9) Distemper → Cement Paints (Water)

Cement paints :-

Cement is the main constituent besides a colouring pigment in powder form.

used → both external and internal.

cannot be used on metals and timber.

Distemper :- Finishing Coat Paints used only on the interior walls.

— mainly consists of whiting and glue size in water.

For colouring → Pigment is added.

— Provide a more durable smooth and pleasing final surface

— will peel off during wet seasons

Miscellaneous Paints :-

Graphite paint :- It is a black paint used on iron parts in mines and other underground works

— resistant to corrosion by a variety of chemicals such as chlorine, ammonia, and compounds of sulphur.

Luminous Paints :- It is a special purpose paint

— Made by dissolving Calcium Sulphide in Varnish.

— The paint emits light after the light source is discontinued.

— used for signboards or road signs

Inodorous Paint :-

Paints containing turpentine emit offensive smells. For obtaining odourless paints, Methylated spirit is used as a solvent.

Silicate Paint :-

It is prepared by mixing together finely powdered Calcined silica and a resinous substance. The paint is resistant to chemical attacks and also against heat.

- used in boilers
- Ovens
- On Concrete and Masonry.
- resistant against ultraviolet radiation.

Varnishes :-

A Varnish may be defined as "a homogeneous liquid containing essentially a resinous substance dissolved in a suitable oil & a volatile liquid".

- A Varnish does not contain a pigment, Moreover, it is always used as a finishing coat.
- Mostly Commonly a Varnish is used over a wooden object as a decorative and protective covering
- Varnish brings out the grain of wood in a brilliant manner when given without a pigment.

UNIT-III

B-III a) Give the percentage proportions of various ingredients of cement with their functions. Also Write the importance of the compounds C_2S and C_3S in cement. **08**

or

(b)Give the IS classification of sand for making concrete. What type of sand is to be used for underground filling and why?

Ingredients of Cement and their functions :-

The two main ingredients of Ordinary Portland cement are

i) Argillaceous → refers to clay.
ii) Calcareous → refers to Calcium Carbonate

The Percentages of Various ingredients in cement are as under

i) Lime (CaO) : 60 to 67 %. → Important ingredient of Cement ; Imparts Strength.
ii) Silica (SiO_2) : 17 to 25 %. — Imparts Strength
iii) Alumina (Al_2O_3) : 3% to 8%. → makes Cement set quickly.
iv) Calcium Sulphate (Gypsum) ($CaSO_4$) : 3 to 4 %. → retards the setting action of Cement.
v) Iron oxide (Fe_2O_3) : 0.5 % to 6 %. → (gives colour, Hardness, Strength)
vi) Magnesium oxide (MgO) : 0.1 to 4 %. → imparts hardness and colour
vii) Sulphur trioxide (SO_3) : 1% to 2.75 %. — Imparts Soundness

C_2S :- Normally 32% of Cement. (25 to 40%)

- It hydrates and hardens slowly and takes long time to add to the strength (after a year or more).
- It imparts resistance to chemical attack.
- Raising of C_2S content renders clinker harder to grind, reduces early strength, decreases resistance to freezing and thawing at early ages and decreases heat of hydration.
- The hydrolysis of C_2S proceeds slowly. At early ages, less than a month, C_2S has little influence on strength and hardness. While after one year, its contribution to the strength and hardness is proportionately almost equal to C_3S.

C_3S

- Normally about 40% (25-50%) of Cement.
- It is supposed to be the best cementing material and is well burnt cement.
- It renders the clinker easier to grind, increases resistance to freezing and thawing, hydrates rapidly generating high heat and develops an early hardness and strength.
- Raising of C_3S content beyond the specified limits increases the heat of hydration and solubility of Cement in water.
- C_3S is mainly responsible for 7 days strength and hardness.

or

Classification of Sand :- (for making concrete)

Depending on the Various sizes of Percentage of the Sand present in a sample, Sand for making concrete is grouped into five zones.

Zone – I (Very Coarse)
Zone – II (Coarse)
Zone – III (Fine)
Zone – IV (Very fine)
Zone – V

Grading of fine aggregates for Concrete – Zones I to V (IS. 383-1970)

	millimetre				microns		
IS Sieve Size	10	4.75	2.36	1.18	600	300	150
Zone – I	100	90-100	60-95	30-70	15-34	5-20	0-10
Zone – II	100	90-100	75-100	55-90	35-59	8-30	0-10
Zone – III	100	90-100	85-100	75-100	60-79	12-40	0-10
Zone – IV	100	95-100	95-100	90-100	80-100	15-50	0-15
Zone V	—	—	100	100	85-100	45-95	0-60

Sand for filling :-

Sand used for filling underground floors has to reduce the capillary suction by which water will travel from foundation soil to the floor. — This will require coarse sand with large voids between the grains.

UNIT-IV

B-IV a) What is meant by water cement ratio of concrete? Give the properties of concrete in plastic and hardened states. **08**

or

(b)Explain in detail the pullout resistance test to assess the compressive strength of concrete

Water – Cement Ratio :-

Water – Cement ratio as the ratio of the weight of mixing water to the weight of cement used in the concrete.

– The strength of concrete increases with decreasing water – cement ratio.

– The minimum grade of concrete specified by IS 456(2000) for structural work in buildings is M20.

– Max water – cement ratio → 0.55.

– min cement content → 300 kg/m³.

– ~~Max cement content → 450 kg/m³~~.

Properties of Concrete :-

1) Very strong in compression. (In RCC compression is taken by concrete and tension by steel)
2) It is durable under normal conditions of exposure.
3) It can be moulded into any form.
4) Its expansion matches with that of steel. (10×10^{-6} to 14×10^{-6} per degree Centigrade)
5) It prevents steel from corrosion, steel corrods when exposed to air. Hence concrete cover is very important in R.C. work.
6) Economical in cost. (compared to steel)
7) It can be made of the materials available locally.
8) Can be manufactured to special requirements.
   – high strength concrete
   – self compacting concrete
   – air entrained concrete
   – Prepack concrete. (additives)
9) Ideal material for gravity structures like dams and retaining walls

Properties of Cement Concrete :-

classified in two categories.

① properties of concrete in plastic stage
② properties of hardened concrete.

I Properties of concrete in plastic stage

Workability :- It is a measure of ease with which concrete can be handled from the mixer stage to its final fully compacted stage.

The proportion and properties of water, cement and aggregates, influence the workability of the concrete. According to I.S.I " the workability is that property of concrete which determines the amount of internal work necessary to produce full compaction.

Elements that affect workability can be listed as follows

(a) Quantity of water in the mix.
— Increased amount of water increases the workability

(b) Proper grading of the aggregate mix.
— If F.A as well as C.A are properly graded, workability is increased.

(c) Increased amount of cement will also increase workability as more water will have to be added to maintain constant W/C ratio.

(d) Ratio of F.A and C.A :- If proportion of C.A. is reduced in relation to F.A. workability can be improved.

(e) If aggregates with rounded grains are used, the workability is improved.

(f) By adding admixtures workability can be increased.

(g) Max size of C.A also affects workability.

(h) Method of compaction of concrete also affects workability. In case concrete is to be compacted by vibrators rather stiff or less workable concrete can be used. workability of concrete is measured by slump test.

ii) Segregation :- Tendency of separation of C.A. grains from the concrete mass is called segregation. It increases when concrete mixture is lean, and too wet. It also increases when rather larger and rough textured aggregate is used.
Segregation is harmful to concrete properties.
Phenomenon of segregation can be avoided by
(A) Addition of little air entraining agents in the mix.
(B) Restricting the amount of water to smallest possible amount
(C) All the operations like handling, placing and consolidation are

(d) Concrete should not be allowed to fall from larger heights.

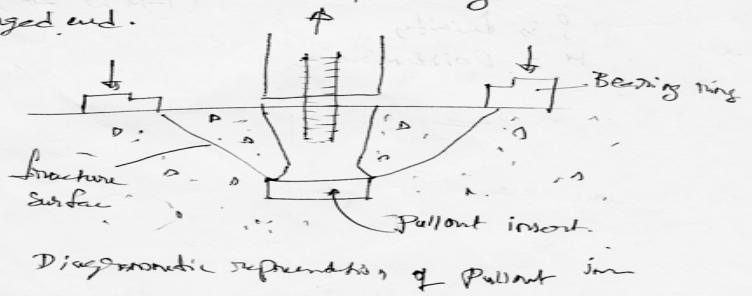
III Bleeding :- The tendency of water to rise to the surface of freshly laid concrete is known as bleeding. The water rising to the surface carries with it, particles of sand and cement, which on hardening form a scum layer popularly known as laitance.
Concrete bleeding can be checked by
(a) By adding more cement
(b) By using more finely ground cement.
(c) By properly designing the mix and using minimum quantity of water.
(d) By using little air entraining agent.
(e) By increasing finer part of fine aggregate.

Properties of hardened Concrete :-

I) Compressive strength
II) Tensile Strength
III) Bond Strength
IV) Impermeability
V) Resistance to wear
VI) Weather and chemical attacks
VII) Shrinkage
VIII) Creep
IX) Thermal expansion
X) elasticity

Pull-out test :-

this is a test which measures, by means of a special tension jack, the force required to pull out a previously cast-in metal insert with an enlarged end.



Diagrammatic representation of Pullout test

- the pullout test is superior to the rebound hammer test and to the penetration resistance test because a larger volume and a greater depth of concrete are involved.

UNIT-V

B-V a) Describe the properties and uses of polymer concrete **08**
or
(b)Describe the properties and uses of light weight concrete

a)

POLYMER CONCRETE

Polymer concrete is part of group of concretes that use polymers to supplement or replace cement as a binder. The types include polymer-impregnated concrete, polymer concrete, and polymer-Portland-cement concrete. Polymers in concrete have been overseen by Committee 548 of the American Concrete Institute since 1971.Contents 1 Composition, 2 Uses, 3 Advantages,4 Disadvantages,5 Specifications, 6 References

Composition

In polymer concrete, thermosetting resins are used as the principal polymer component due to their high thermal stability and resistance to a wide variety of chemicals. Polymer concrete is also composed of aggregates that include silica, quartz, granite, limestone, and other high quality material. The aggregate must be of good quality, free of dust and other debris, and dry. Failure to fulfil these criteria can reduce the bond strength between the polymer binder and the aggregate.

Uses

Polymer concrete may be used for new construction or repairing of old concrete. The adhesive properties of polymer concrete allow patching of both polymer and conventional cement-based concretes. The low permeability and corrosive resistance of polymer concrete allows it to be used in swimming pools, sewer structure applications, drainage channels, electrolytic cells for base metal recovery, and other structures that contain liquids or corrosive chemicals. It is especially suited to the construction and rehabilitation of manholes due to their ability to withstand toxic and corrosive sewer gases and bacteria commonly found in sewer systems. Unlike traditional concrete structures, polymer concrete requires no coating or welding of PVC-protected seams.[1] It can also be used as a replacement for asphalt pavement, for higher durability and higher strength.

Polymer concrete has historically not been widely adopted due to the high costs and difficulty associated with traditional manufacturing techniques. However, recent progress has led to significant reductions in cost, meaning that the use of polymer concrete is gradually becoming more widespread.

Advantages

1. Advantages of polymer concrete include:
2. Rapid curing at ambient temperatures;

5. Good long-term durability with respect to freeze and thaw cycles
6. Low permeability to water and aggressive solutions
7. Good chemical resistance
8. Good resistance against corrosion
9. Lighter weight (only somewhat less dense than traditional concrete, depending on the resin content of the mix)
10. May be vibrated to fill voids in forms
11. Allows use of regular form-release agents (in some applications)
12. Dielectric

Disadvantages

Product hard to manipulate with conventional tools such as drills and presses due to its strength and density. Recommend getting pre-modified product from the manufacturer
Small boxes are more costly when compared to its precast counterpart however pre cast concretes induction of stacking or steel covers quickly bridge the gap.

Specifications

Following are some specification examples of the features of polymer concrete:

Density 2260kg/m3 Compressive strength 37 MPa

Or

b) LIGHT WEIGHT CONCRETE

Light weight concrete - or foamed concrete - is a versatile material which consists primarily of a cement based mortar mixed with at least 20% of volume air. The material is now being used in an ever increasing number of applications, ranging from onestep house casting to low density void fills.

Foamed concrete has a surprisingly long history and was first patented in 1923, mainly for use as an insulation material. Although there is evidence that the Romans used air entrainers to decrease density, this was not really a true foamed concrete. Significant improvements over the past 20 years in production equipment and better quality surfactants (foaming agents) has enabled the use of foamed concrete on a larger scale.

Lightweight and free flowing, it is a material suitable for a wide range of purposes such as, but not limited to, panels and block production, floor and roof screeds, wall casting, complete house casting, sound barrier walls, floating homes, void infills, slope protection, outdoor furniture and many more applications.

Not everyone knows that density and compressive strength can be controlled. In the light weight concrete this is done by introducing air through the proprietary foam process which enables one to control density and strength precisely.

Normal concrete has a density of 2,400 kg/m3 while densities range from 1,800, 1,700, 1,600 down to 300 kg/m3. Compressive strengths range from up to 40 Mpa down to almost zero for the really low densities. Generally it has more than excellent thermal and sound insulating properties, a good fire rating, is non combustible and features cost savings through construction speed and ease of handling.

The technology is the result of over 20 years of R&D, fine tuning the product and researching the possible applications. It is used in over 40 countries worldwide today and has not reached the end of its possible uses.

Strength is a relative term. Concrete mixes should be designed based on end use. High compressive strength is useful where dead load or abrasion are factors, but are unnecessary for roofs and non-structural partitions. All concrete is deficient in tensile and shear strengths; however these are supplemented through structural reinforcement. Compressive strength can be made up to 40 Mpa, exceeding most structural requirements.

Advantages of pre-formed foam

The pre-formed foam process offers excellent quality control and assurance of specified density. Preformed foam, unlike gas-forming chemicals, assures a consistent three-dimensional distribution of the engineered air cell system. Pre-formed foam produces a consistent matrix of relatively small air cells which are more desirable than a

disorganized matrix of different size bubbles often created with the gas method of reactive admixtures.

Disadvantages of lightweight concrete

In the lower density ranges lightweight concrete does not develop the compressive strength of plain concrete. While this may be a disadvantage in plain concrete applications, it is an advantage in a lightweight concrete application. It should be considered that lightweight concrete and plain concrete are typically used for different types of applications. Each form of concrete exhibits a unique family of performance characteristics. Each should be utilized in the appropriate type of project. But a high strength of 33 Mpa has been achieved with a high cement content mix.

Densities and Strengths

One of the most useful features of a lightweight concrete system is the system's ability to be manufactured in a wide range of low densities and strengths. Application requirements for lightweight concrete range from very light density low strength fill dirt replacement to higher strength structural lightweight concrete. To accommodate this wide range of performance properties lightweight concrete has developed a mix design chart, which will illustrate the basics of making this wide range of materials from just one lightweight concrete concentrate. With a lightweight concrete foam generator and a single liquid foam concentrate the contractor now has available to them a wide variety of cost effective, high performance, lighter lightweight concrete products.

Different densities and strengths

Lightweight concrete exhibits a much lighter density than typical aggregate concrete. Typical plain concrete has a density of 2400 kg/m3, lightweight concrete densities range from 300 kg/m3 to 1800 kg / m3. Lightweight concrete is an insulator and can be used in a variety of applications which require an insulating material that can also exhibit some integrity and strength. Lightweight concrete at its lightest density is still more stable and strong than well compacted soil. When replacing soils, lightweight concrete can be designed to provide whatever strengths and characteristics needed for the soil stabilization project. Some soil engineers lightheartedly refer to lightweight concrete used in Geotechnical stabilization projects as "designer dirt." They know that lightweight concrete can be specified to easily exceed whatever compacted soil requirements are needed.

lightweight concrete cost

Cost effective lightweight concrete varies in price by geographical area and by application requirements such as density and strength requirement. A typical concrete structure project will be much less expensive cubic meter to cubic meter when compared to plain concrete due to labour savings, less cost of forming works, less steelworks, eliminate brickworks, cement renderings work and the price savings is very substantial when compare to conventional methods.

suitable for long-term use as a marine float device

At the lower densities, lightweight concrete will float, and in many cases float indefinitely. Because of its limited impact and abrasion resistance, lightweight concrete used for marine flotation should be encased and used for the fill of a float. For example, a marine float could be made with sealed drums filled with low-density lightweight concrete.

How to produce lightweight concrete

The pre-formed foam is added to the cement slurry and mixed in the concrete mixer or in a continuous process. From that point, lightweight concrete is placed in any way that a fluid mix can be transported. Pumping is the most common method of placement. Tailgate ready mix truck delivery, bucket cranes, wheelbarrows, hand carried buckets and any other acceptable method of delivering a fluid mix works well.

Later, 60-100 MPa concrete mixtures were commercially developed and used in the construction of high-rise
buildings and long-span bridges in many parts of the world.

X